A Curious Mission: An Analysis of Martian Molecules

by
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Part I – Biochemical Analysis of Atmospheric Sample

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Johnson Space Center
Houston, TX

5:53am
In the parking lot at Johnson Space Center, the morning dew is just beginning to evaporate into a misty haze that envelops you as you step out of your car. The campus is quiet, except for the baying of the longhorn cows in the pasture nearby.

You make your way to Building C, say hello to the security guards who are nearing the end of their shift, and walk through the double glass doors into the research wing. Once through the doors, the quiet disappears. The hallways are abuzz with energy and chatter about what the day will hold. In a few minutes, a very special delivery will be made and the most important work of your life will begin. This is the day you have been waiting for since elementary school.

You head into the clean room entry area, put on your sterile white suit, shoe covers, and gloves, and step through the revolving door into the clean room. Sheila and Marcus are already inside, getting the gas chromatograph ready and speculating about what they will find. You double-check that all of the equipment you will need is set out and ready for use, then pull your laboratory notebook from the shelf. Turning to a new page, you write a title across the top of the blank sheet: *Sample Analysis—Materials Returned to Earth by Mars Curiosity Mission 5.*

6:21am
The revolving door spins open and Alexa bursts into the room holding a clear glass cylinder. "It's here!" she exclaims. "Are you guys ready?" The cylinder appears to be empty, but in fact it holds a precious sample of the Martian atmosphere, collected by the Mars Curiosity 5 rover from an area within the Gale Crater. You and your team have been given the task of analyzing the molecular makeup of the air inside the cylinder using GC-MS (gas chromatography-mass spectrometry). Gas chromatography will allow you to separate the compounds in the sample, and mass spectrometry will detect the molecular weight of each individual molecule. You inject some of the gas sample into the GC-MS instrument and wait anxiously for the results.

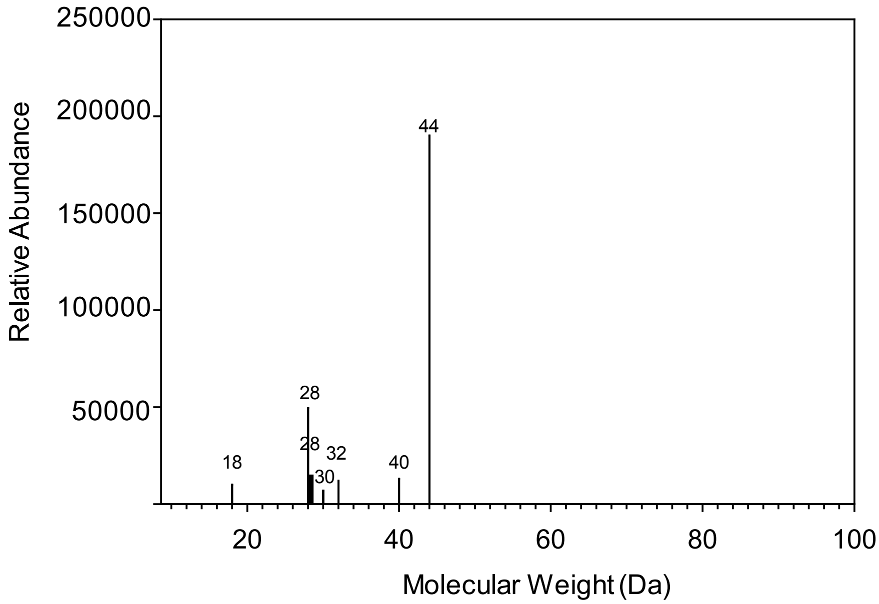

Figure 1: Results from the gas chromatography-mass spectrometry analysis of the Gale Crater atmospheric sample. (Note that there are two peaks at 28 Da. How do you interpret those seemingly redundant data?)

Data Analysis of Atmospheric Sample

Assignment 1: Refer to the background reading you have been given about the conditions of Mars. Use that information to identify the atoms or molecules that correspond to the seven peaks identified in Figure 1. List each of the molecules and give their chemical formula and molecular weight.

Atom/Molecule	*Chemical Formula*	*Molecular Weight*

Assignment 2: Draw the molecular structure of each of the molecules you identified in the sample of Martian atmosphere. To do this, you will need to determine the number of valence electrons for each atom to decide if the bonds between atoms will be single, double, or triple bonds. In your drawings, you must also show any lone pair electrons not participating in the bonds. Use your knowledge of electronegativity to determine whether the bonds that will be formed between the atoms of each molecule are polar or nonpolar, and write the polarity beneath each molecule. Indicate any partial charges as appropriate.

Atom/Molecule	*Drawing of Molecular Structure*

Atom/Molecule	*Drawing of Molecular Structure*

Making Predictions about the Atmospheric Sample

Assignment 3: Based on the atomic content of the molecules you identified in the Mars atmospheric sample, predict whether the following molecules that exist on Earth could be produced. List the molecules in the Martian atmosphere that contain the necessary atoms to build them, or if you predict that they could not be constructed, list the atoms that are missing from what you found in the atmospheric molecules.

a. *DNA:*

b. *Glucose:*

c. *Valine (amino acid):*

d. *Cysteine (amino acid):*

e. *Fatty acid:*

f. *Phospholipid:*

Assignment 4: Look at the list of molecules that are present in the Martian atmosphere. Compare this list with the predicted components that were present in the atmosphere of ancient Earth.

Martian atmosphere:

Ancient Earth atmosphere:

Assignment 5: Based on your predictions about which of the molecules that exist on Earth could be produced from the atmospheric contents of Mars, do you think that life on Mars could exist? If so, which of the Mars atmospheric molecules or conditions would be important for creating the necessary molecules for life? If not, what additional molecules or conditions would be required to make life possible? Explain your reasoning.

Part II – Geological Analysis of the Gale Crater

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1:03pm

After lunch, you suit up and head back into the clean room to find a new package awaiting you on the lab bench. You open the wooden crate to find a glass box filled with soil and rocks collected from within the Gale Crater. Using atomic absorption spectroscopy, you will be able to identify the major elements within the sample.

3:17pm

Marcus emerges from the analysis room and shouts, "The results from the chemical analysis are in!" Examining the data sheet, you can see that the geological sample contains several new elements that were not present in the atmospheric sample:

Element	*Atomic Mass (Da)*	*Percent Abundance*
Si	28.085	20.9
Fe	55.845	12.7
S	32.06	3.1
P	30.974	<0.25

Experimental Design – Could Life Exist on Mars?

Assignment 6: Now you have a complete list of the atoms and molecules present on Mars, both in the atmosphere and in the soil. Use your knowledge of the conditions of ancient Earth and the atomic components of the essential molecules of life on Earth to predict whether life could exist on Mars. Explain your reasoning thoroughly.

Assignment 7: In your groups, write an outline that describes an experiment to determine if life could exist on Mars. Refer to Miller's Spark-Discharge experiment as well as the discussion of the RNA world in your textbook for ideas. During the next class session, we will discuss your ideas as a group.

Image Credits: The title block image, "Daybreak at Gale Crater," is a computer-generated view of part of Mars that includes Gale Crater beginning to catch morning light. NASA/JPL-Caltech, from http://www.nasa.gov/mission_pages/msl/multimedia/gallery/pia14293.html. Photo of Microsystems Fabrication Laboratory at NASA Glenn (on page 1) by Marvin Smith (WYLE), from http://www.nasa.gov/centers/glenn/multimedia/imagegallery/if035_clean_room2.html#.UtX2DbRLkmY.